Crumb Rubber Use in Artificial Athletic Turf

SHEENA AHRAR

ENVIRONMENTAL HEALTH, MPH

The project on which this presentation is based was completed in collaboration with the City of Brooklyn Park as part of the 2016-–2017 Resilient Communities Project (RCP) partnership. RCP is a program at the University of Minnesota’s Center for Urban and Regional Affairs (CURA) that connects University faculty and students with Minnesota communities to address strategic projects that advance local resilience and sustainability.

The contents of this report represent the views of the authors, and do not reflect those of RCP, CURA, the Regents of the University of Minnesota, or the City of Brooklyn Park.

This publication may be available in alternate formats upon request.

Resilient Communities Project
University of Minnesota
330 HHHSPA
301—19th Avenue South
Minneapolis, Minnesota 55455
Phone: (612) 625-7501
E-mail: rcp@umn.edu
Web site: http://www.rcp.umn.edu

Introduction

Brooklyn Park

- Athletic fields heavily used
  - Degrading soil quality
  - Limits usage of field
- Re-evaluating athletic fields
  - Multi-purpose fields
  - Multi-season fields

Considering artificial turf

Background

Crumb Rubber

Crumb rubber is any material derived from reducing scrap tires or other rubber into uniform granules

Ground rubber application is an important market for the recycling of scrap tires

- Accounting for 25% of total volume of repurposed scrap tires

Synthetic Turf Fields

Approximately 12,000 – 13,000 artificial turf fields

Each containing approximately 100 tons of crumb rubber

Image from: http://www.brockusa.com/2017/03/stubhub-center-embraces-la-spec-brock/

Synthetic Turf Fields

BENEFITS

Reduced water use

Increased number of playable days

Minimum maintenance

Utilizes recycled materials

CONCERNS

Tires contain a wide range of hazardous chemicals

Contaminants Identified in Crumb Rubber

Volatile Organic Compounds (VOCs)
Nitrosamines
Xylenes
Heavy Metals
Zinc
Lead
Other
Polycyclic Aromatic Hydrocarbons (PAHs)
Benzothiazoles
Phthalates

Exposure Assessment

Oral Exposure: Lead

Absorption rate – dependent on particle size and age of the person exposed

Toxicological effects can occur at low concentrations in children

EPA guidance levels for residential soil:

- 400 ppm in play areas
- 1200 ppm in non-play areas

Oral Exposure: Lead

Kim et al.

Assessed the hazard of lead in crumb rubber with particle sizes <250 μm and >250 μm, considering bioavailability

Hazard Quotient

Particle Size	Low grade Elementary	Middle/High school
<250 μm	0.260	0.081
>250 μm	0.093	0.029

Oral Exposure: Lead

Zhang et al.

- Analyzed lead concentration in crumb rubber
- Using digestive fluids (saliva, gastric fluid, and intestinal fluid) determined bioaccessible fractions of lead
  - Bioavailability ranged from 24.7 – 44.2%

Lead Concentrations (ppm)
5.76
4.63
3.12
53.5

Oral Exposure: Zinc

Zinc – an essential element to the human diet

EPA oral reference dose (RfD) 0.3 mg/kg/day

New York State DEC, public health protection limit

- 2200 ppm in residential areas
- 2480 ppm ground water

Zinc has been detected at high concentrations in crumb rubber well above the DEC soil limit

Oral Exposure: Zinc

Leaching into Groundwater – *New York State DEC*

- Four existing artificial turf fields (ages 1 – 7 years)
- First analyzed the potential for chemical release from crumb rubber using a simulated precipitation leaching procedure
  - Average concentration 1947 μg/L and 1150 μg/L for 1st and 2nd SPLP
- Then conducted a surface water survey and ground water survey
  - Runoff samples: zinc detected at 58.5 μg/L,
  - Groundwater survey: all below the limit of detection

Oral Exposure: PAHs

Polycyclic Aromatic Hydrocarbons (PAHs)

- Group of semi-volatile chemicals formed during incomplete combustion
- There are more than 100 different PAHs, generally occurring as complex mixtures

Background levels reported to be 0.02 – 1.2 ng/m^3 in rural areas, and 0.15 – 19.3 ng/m^3 in urban areas

Carcinogenicity

- BaP – Group 1 Carcinogen**
- Chrysene – Group 2B**

Oral Exposure: PAHs

Zhang et al.

Analyzed the chemical content of crumb rubber

Evaluated the bioaccessible fractions of PAHs

- Three synthetic digestive fluids to simulate bioavailability
- Zero bioaccessibility

Substance	DEC Soil Limit	Sample 1	Sample 2	Sample 5
Benzo[a]anthracene	1 ppm	1.23 ppm	1.26 ppm	NA
Benzo[a]pyrene	1 ppm	8.58 ppm	3.56 ppm	NA
Benzo[b]fluoranthene	1 ppm	3.39 ppm	2.19 ppm	1.08 ppm
Benzo[k]fluoranthene	1 ppm	7.29 ppm	1.78 ppm	NA

Inhalation: VOCs

Volatile Organic Compounds (VOCs)

- Evaporate easily
- Repeated exposures to high levels of VOCs may cause them to build up in the body

In tires, VOCs are bound within the rubber matrix, but when recycled into crumb rubber the reduction to smaller sizes, weather, and high air/field temperatures allows VOCs to be released from the matrix in vapor phase, entering the breathing zone of humans

Inhalation: VOCs

Ginsberg et al.

Investigated 5 artificial turf fields, using volunteer soccer players

- Samples were collected by personal sampling devices in the breathing zone of children, and with stationary monitors
- Control – grass field
- Results: identified 10 VOCs as contaminants of potential concern due to high concentrations above background levels
- Risk characterization scenarios (child outdoor/indoor, adult outdoor/indoor for cancer and non-cancer risks were below minimal levels of concern

Inhalation: Particulate Matter

PM, a term used to describe a mixture of solid particles and liquid droplets found in the air

Two ranges of respirable concern; PM_{10} and $PM_{2.5}$

EPA daily standard for PM_{10} and $PM_{2.5}$ is 150 $\mu g/m^3$ and 35 $\mu g/m^3$ respectively

EPA annual standard for $PM_{2.5}$ is 12 $\mu g/m^3$

Inhalation of PM from crumb rubber may be a potential concern as running may break down the material, emitting particles into the air

Inhalation: Particulate Matter

Air quality monitoring survey – *New York State DEC*

- PM concentrations were obtained for PM_{10} and $PM_{2.5}$
- Samples collected during field use
- Particle Analysis revealed bi-modal distribution of both very large and very small particles
  - Composition for large particles: rubber, grass, and cord material
  - Composition for small particles: crustal minerals, and biologicals (pollen or mold)
  - Crumb rubber dust was not found in the respirable range

Dermal Exposure: PAHs

Recently there has been growing awareness that the absorption of PAHs through the skin can be very substantial

Currently no regulations or exposure limits established for dermal exposure to PAHs

Dermal Exposure: PAHs

Rooij and Jongeneelen

Evaluated the uptake of PAH by soccer players

- Urine of athletes was collected over a three-day period (day before, day of, and day after sporting)
- Urine samples analyzed for 1-hydroxypyrene (biomarker)
- 2.5 hour period playing on the field
- Urine samples did not reveal an increase in PAH

Dermal Exposure: Skin Sensitization

California OEHHA

Skin sensitization study: guinea pigs

- 5 of the 10 positive control group showed positive skin reactions at 24 hours after re-challenge, with 4/10 also exhibiting positive skin reactions at 48 hours
- However, none of the crumb rubber treatment groups contained any animal with positive allergic response

Other Relevant Studies

Dorsey et al.

Evaluated the mutagenic potential of crumb rubber at increased temperatures

- Collected infill from 4 artificial turf fields
- Leachates were made from these samples at a range of temperatures
- Samples assayed for mutagenic potential (*Salmonella typimurium* TA 100 cells)
- Results:
  - Leachates obtained in water 70˚C had significant mutagenic potential ($p \leq 0.001$)
  - Leachates obtained in water 40 ˚C showed no mutagenic potential

Conclusion

Conclusion

Based on available data, there is low likelihood of adverse health effects for children and athletes exposed to crumb rubber in artificial turf

Conclusion

Oral:

- PAHs are not bioavailable when ingested
- Zinc has been detected at high levels in crumb rubber surpassing soil standard limits, but there has been no assessment on its bioavailability
- Lead has been shown to be bioavailable (24.7-44.2%) even at low concentrations, but the hazard quotient for children was below 1

Conclusion

Inhalation:

- VOCs have been measured at various concentrations, but risk characterization scenarios revealed risk of cancer and non-cancer risk levels were below minimal levels of concern
- PM measurements during active field use showed that crumb rubber did not produce respirable particles

Dermal:

- PAHs are not likely to absorb through the skin
- Skin sensitization has not been observed in animal studies

Recommendation

If it is financially feasible and beneficial to upgrade their athletic fields, I recommend the use of artificial turf containing crumb rubber

However, parents may still oppose the use of crumb rubber regardless of scientific evidence

Questions?

References

California Integrated Waste Management Board, *Evaluation of Health Effects of Recycled Waste Tires in Playground and Track Products*. 2007, Integrated Waste Management Board: Sacramento, CA.

Dorsey, Michael J., et al. (2015). Mutagenic Potential of Artificial Athletic Field Crumb Rubber at Increased Temperatures. *Ohio Journal of Science*, 115(2):32 – 39.

Ginsberg, Gary, et. al. (2011). Human Health Risk Assessment of Synthetic Turf Fields Based Upon Investigation of Five Fields in Connecticut. *Journal of Toxicology and Environmental Health*. 74 (17): 1150 – 1174.

Kim, Sunduk, et. al. (2012). Health Risk Assessment of Lead Ingestion Exposure by Particle Sizes in Crumb Rubber on Artificial Turf Considering Bioavailability. *Environmental Health and Toxicology*, 27.

Lim, L. and R. Walker. *An Assessment of Chemical Leaching, Releases to Air and Temperature at Crumb-Rubber Infill Synthetic Turf Fields*. New York State Department of Environmental Conservation and Department of Health, Editor. 2009.

Van Rooij, Joost G.M., and Frans J. Jongeneelen (2010). Hydroxypyrene in urine of football players after playing on artificial sports field with tire crumb infill. *Int. Arch. Occup Environ Health*; 83: 105 – 110.

Zhang, Junfeng, et. al. (2008). Hazardous Chemicals in Synthetic Turf Materials and Their Bioaccessibility in Digestive Fluids. *Journal of Exposure Science and Environmental Epidemiology*, 18:600 – 607.